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WORK-HARDENED STAINLESS STEEL SHEET

INDUSTRIAL FIELD

The present invention relates to work-hardened stainless steel sheets, having ferritic structures strengthened by work-hardening for improvement of strength and bendability.

BACKGROUND OF THE INVENTION

There is a demand for lightening members, which are built in home electric appliances or office automation devices, e.g. televisions and personal computers, especially portable notebook computers. Such lightening is achieved by reducing thickness of members, but strength necessary for use shall be assured regardless of reduction of thickness. In this regard, steel material with 0.2% offset yield strength of at least 500 N/mm^2 or Vickers hardness of at least HV200 has been used for the purpose.

Frames or casings, which are built in home electric appliances or office automation devices, are manufactured by pressing or bending cut sheets to objective profiles. Therefore, metal material for the use shall have good bendability in addition to mechanical properties.

By the way, provision of naked metal material without necessity of plating or coating has been earnestly demanded in these days, aiming at environmental protection and recyclability. Representative naked metal material with good corrosion-resistant is martensitic stainless steel, e.g. SUS410 or SUS420J2, precipitation-hardening stainless steel, e.g. SUS631, or work-hardening austenitic stainless steel, e.g. SUS304 or SUS301.

Martensitic or precipitation-hardening stainless steel is strengthened by heat-treatment such as quenching and tempering or aging, after it is formed to an objective profile. However, such heat-treatment is carried out by a fabricator, so that the fabricator has to bear responsibility for a cost of

heat-treatment equipment. It is also necessary to pickle or grind a heat-treated steel sheet for removal of oxide scales and to reform the heat-treated steel sheet for elimination of thermal deformation.

On the other hand, work-hardening austenitic stainless steel has enough strength in a state of sheet material with good bendability for a fabricator to omit heat-treatment, but is expensive due to addition of Ni at a high ratio. In this regard, there are several proposals on reduction of a Ni content for saving steel costs without degrading advantages of work-hardening austenitic stainless steel. For instance, a ferritic/martensitic dual-phase stainless steel (JP 63-169330 A), wherein its strength and formability are improved by a martensitic phase and a ferritic phase, respectively. A stainless steel (JP 11-302791 A), wherein its bendability is improved by size- and shape-control of MnS inclusions, which are dispersed in a ferritic/martensitic dual-phase or martensitic single phase. A stainless steel (JP 2001-262282 A), wherein a ferritic structure is work-hardened without heat-treatment.

The ferritic/martensitic dual-phase stainless steel (JP 63-169330 A) has strength, which can be raised by an increase of a ratio of a martensitic phase, but its bendability is significantly worsened at an excess ratio of a martensitic phase above 50 mass %.

The stainless steel (JP 11-302791 A) is mainly used as rectangular pipes with a relatively large bend radius for building constructions. On the other hand, frames, casings or cabinets of home electric appliances are prepared by forming steel sheets to objective profiles with a bend radius remarkably smaller than the rectangular pipes. With the small bend radius, a dual-phase or martensitic single phase stainless steel sheet is often cracked during formation to a profile of a frame, casing or cabinet, even if MnS is properly controlled in size and shape.

How to control size and shape of MnS is not concretely disclosed in

JP 11-302791 A. It is well-known that bendability of a steel sheet is worsened by string-shaped MnS, which is expanded along a rolling direction. MnS is further expanded as an increase of a cold-rolling reduction and finally distributed as fine particles in a steel matrix. As a result, MnS is made harmless due to fine dispersion as for a thin steel sheet, but still harmful on a relatively thick steel sheet, wherein dispersion of MnS as fine particles can not be expected. Moreover, various alloy designs are necessary in order to ensure proper strength in response to variation of uses, since strength of dual-phase or martensitic single phase stainless steel without heat-treatment is predominantly determined by alloying composition.

A cold-rolling method for work-hardening a ferritic structure is advantageous for improvement of bendability, compared with strengthening by martensitic transformation. However, JP 2001-262282 A is directed to disc brakes of motorcycles, which are manufactured from stainless steel sheets without bending. A steel sheet, which is manufactured under the proposed conditions, is not proper material for frames, casings or cabinets, since it is often cracked during bending with a small bend radius.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a strengthened stainless steel sheet, which can be formed to an objective profile without cracking even under severe fabricating conditions. Another object of the present invention is to improve formability and strength of a stainless steel sheet by combination of desulfuring and deoxidizing with Al for modification of inclusions to fine Al_2O_3 or $Al_2O_3 \cdot MgO$ particles and by cold-rolling for formation of a work-hardened ferritic structure without necessity of heat-treatment.

The inventive work-hardened stainless steel sheet is characterized by its chemical composition and metallurgical structure.

The stainless steel has a composition consisting of 0.15 mass % or less of C, 1.0 mass % or less of Si, 1.0 mass % or less of Mn, 0.005 mass % or less of S, 10-20 mass % of Cr, 0.5 mass % or less of Ni, 0.001-0.05 mass % of Al and the balance being substantially Fe. The stainless steel may further contains at least one selected from the group consisting of 0.5-2.0 mass % of Mo, 0.5-2.0 mass % of Cu and 0.05-1.0 mass % of Nb.

The stainless steel has a work-hardened ferritic structure, wherein Al_2O_3 and/or $Al_2O_3 \cdot MgO$ are distributed as fine particles of 10 μm or less in size with an index of cleanliness of 0.06% or less. Its 0.2% offset yield strength is preferably controlled to a value within a range of 500-900 N/mm^2 by a cold-rolling reduction.

PREFERED EMBODIMENT OF THE INVENTION

MnS, an inclusion harmful on bendability, is relatively soft and expanded along a rolling direction during cold-rolling, so that it is dispersed as strings in a steel matrix. When such a stainless steel sheet is bent, MnS acts as starting points of cracks due to stress concentration thereon. Mere desulfurization is insufficient for harmlessness of MnS, but the MnS inclusion is necessarily controlled in composition, size and shape for inhibition of cracks.

The MnS inclusion changes its composition, size and shape in response to a kind of a deoxidizing agent, which is added to a molten steel in a steel-refining step. When Si is added as a deoxidizing agent for instance, $MnO \cdot SiO_2$ and/or $MnO \cdot SiO_2 \cdot MnS$ are formed other than MnS. Another deoxidizing agent Ti inhibits formation of string-shaped inclusions, but forms TiN in addition to TiO_2 as a deoxidation product. The reaction products coalesce together into coarse clusters, which will cause surface defects on a stainless steel sheet. Ti-deoxidation is also accompanied with plugging of a tundish nozzle, unless a N content of molten steel is specifically reduced.

The inventors have researched and examined various processing conditions for inhibition of such inclusions as MnS, MnS, $MnO \cdot SiO_2$ and $MnO \cdot SiO_2 \cdot MnS$, which worsen bendability of a steel sheet and also degrade an external appearance of the steel sheet. In the course of researches, the inventors have discovered that bendability of a steel sheet is surprisingly improved by specified deoxidation with Al, which reforms inclusions to Al_2O_3 or $Al_2O_3 \cdot MgO$ type. In fact, a steel sheet, which has the structure that Al_2O_3 or $Al_2O_3 \cdot MgO$ inclusions of 10 μm in size are distributed in a steel matrix with an index of cleanliness of 0.06% or less by combination of desulfurization and deoxidation with Al, can be formed to an objective profile with good bendability, as explained in the below-mentioned examples.

Since a stainless steel sheet is strengthened by cold-working for formation of a work-hardened ferritic phase, 0.2% offset yield strength suitable for the purpose is imparted to the stainless steel sheet without any special alloy design. Representative cold-working is cold-rolling, and yield strength is adjusted to a value within a range of 500-900 N/mm^2 (i.e. Vickers hardness of 200-300 HV) by control of a cold-rolling reduction. By the way, a ferritic stainless steel sheet in a normally annealed state has yield strength of about 250-300 N/mm^2 (Vickers hardness of about 130-150 HV) too lower than a demand value.

The inventive ferritic stainless steel sheet has the below-mentioned chemical composition with the structure that inclusions are controlled in composition, size and shape.

[Alloy Design]

C: 0.15 mass % or less

C is an alloying element for strengthening a steel matrix, but excess C promotes precipitation of chromium carbide, resulting in poor corrosion-resistance. Therefore, an upper limit of a C content is determined at 0.15 mass % (preferably 0.08 mass %).

Si: 1.0 mass % or less

Si is a ferrite-forming element for strengthening a steel matrix. But excess Si above 1.0 mass % unfavorably promotes precipitation of SiO_2 or $MnO \cdot SiO_2$ inclusions harmful on bendability.

Mn: 1.0 mass % or less

Mn, an austenite-forming element, is dispersed as $MnO \cdot SiO_2$ harmful on bendability in a steel matrix. Therefore, an upper limit of Mn is determined at 1.0 mass % (preferably 0.5 mass %).

S: 0.005 mass % or less

S dissolves in MnS and $MnO \cdot SiO_2$ harmful on bendability and forms coarse oxysulfide particles. In order to inhibit harmful effects of S, an upper limit of S is determined at 0.005 mass % (preferably 0.003 mass %).

Cr: 10-20 mass %

Cr is an essential element for improvement of corrosion-resistance, and a Cr content of 10 mass % or more is necessary for assurance of corrosion-resistance as stainless steel. But excess Cr above 20 mass % degrades toughness of the stainless steel. A Cr content is preferably controlled within a range of 11-18 mass %.

Ni is an austenite-forming element. As an increase of a Ni content, stainless steel lowers its Ac_1 temperature and promotes formation of a martensitic phase at a cooling step during annealing. In this regard, a Ni content is controlled to 0.5 mass % or less in order to inhibit formation of a martensitic phase.

Al: 0.001-0.05 mass %

Al is added as a deoxidizing agent. Sufficient deoxidation effect is achieved by controlling an Al content to 0.001 mass % at least. However, excess Al causes massive precipitation of Al_2O_3 particles. The Al_2O_3 particles coalesce together into clusters, which unfavorably cause surface defects on a stainless steel sheet. In order to control size of Al_2O_3 particles to 10 μm or

less with cleanliness of 0.06% or less, an upper limit of Al is determined at 0.05 mass %. An Al content is preferably controlled within a range of 0.003-0.03 mass %.

Mo: 0.5-2.0 mass %

Cu: 0.5-3.0 mass %

Nb: 0.05-1.0 mass %

Each of Mo, Cu and Nb is an optional element for improvement of corrosion-resistance. Effects on corrosion-resistance is noted at 0.5 mass % or more of Mo, 0.5 mass % or more of Cu or 0.05 mass % or more of Nb. However, excess Mo above 2.0 mass % worsens cold-workability of stainless steel due to its solution-hardening effect, excess Cu above 3.0 mass % worsens hot-workability and productivity of stainless steel, and excess Nb above 1.0 mass % raises a steel cost without improvement of corrosion-resistance any more.

[A work-hardened ferritic structure]

Inclusions, which are dispersed in a steel matrix, are reformed to Al_2O_3 or $Al_2O_3 \cdot MgO$ by desulfurization and deoxidation with Al, and the reformed inclusions are divided to fine particles of 10 μm or less (preferably 5 μm or less) in size by cold-working. The reformation and dividing effectively avoid stress concentration on the inclusions, which often act as starting points of cracks. Consequently, a stainless steel sheet can be formed to an objective profile with even a small radius at a bent part, and cracking is remarkably reduced.

Cold-working is advantageous for strengthening a stainless steel sheet in addition to dividing inclusions to fine particles. Namely, a ferritic stainless sheet, which has yield strength of about 250-300 N/mm^2 (Vickers hardness of about 130-150 HV) in a normally annealed state, is strengthened by work-hardening. Moreover, a value of yield strength can be freely adjusted to a value within a range of 500-900 $N.mm^2$ (Vickers

hardness of 200–300 HV) by control of a cold-working reduction, so that steel material with strength suitable for a purpose is offered without any change of alloy design. In the case where the stainless steel sheet is work-hardened by cold-rolling, a rolling reduction at a finish rolling step is determined within a range of 15–50% (preferably 20–35%) in order to strengthen the stainless steel sheet without degradation of bendability.

The other features of the present invention will be clearly understood from the following examples.

EXAMPLE 1

Molten stainless steel was deoxidized with Si and adjusted to each chemical composition shown in Table 1. A sample S-1 is a stainless steel sheet, which was re-crystallized to a single ferritic structure by annealing in succession to hot-rolling and then cold-rolled to thickness of 1.8 mm with a rolling reduction of 25% for work-hardening the ferritic structure. Samples S-2 and S-3 are stainless steel sheets, each of which was cold-rolled to thickness of 1.8 mm in the same way, held at an elevated temperature in an austenitic/ferritic dual-phase region for a short while and then rendered to a ferritic/martensitic dual-phase structure by air-cooling. The sample S-2 has a ratio of a martensitic phase greater than the sample S-3.

Table 1: Chemical Compositions of Stainless Steels (by mass %)

	C	Si	Mn	S	Cr	Ni	Al
S-1	0.068	0.38	0.39	0.006	12.4	0.4	$<$0.003
S-2	0.023	0.47	0.85	0.004	11.9	0.09	$<$0.003
S-3	0.011	0.24	0.89	0.001	11.7	0.14	$<$0.003

Test pieces for a tensile test regulated as JIS 13B (JIS Z 2201) were

sampled from each stainless steel sheet along two directions, i.e. a longitudinal direction (hereinafter called as "direction-L") and a transverse direction (hereinafter called as "direction-T"). The test pieces were subjected to a tensile test for measuring yield strength and elongation. Test results are shown in Table 2. It is noted that the sample S-1 had yield strength substantially similar to a value of the sample S-2, which had a martensitic phase at a ratio of 80 vol. %, but its elongation was smaller than the sample S-2.

Table 2: Metallurgical Structures and Mechanical Properties

	Metallurgical Structure	Sampling direction of test pieces	Y.S. (N/mm^2)	El. (%)
S-1	work-hardened ferrite	L	689	5
		T	805	3
S-2	80% martensite +20% ferrite	L	708	11
		T	755	11
S-3	50% martensite +50% ferrite	L	591	11
		T	606	12

Y.S.: 0.2% offset yield strength El.: elongation

Bendability of each stainless steel sheet was evaluated by a V-block bend method (a V-block bend test by bending angle of 90 degrees under JIS Z2248). Namely, each test piece was bent at a right angle around an axis in parallel to a rolling direction (hereinafter called as "T-directional bending") and also around an axis orthogonal to the rolling direction (hereinafter called as "L-directional bending") by punches with various radii R of top curvatures, and bendability was represented by a minimum radius R, at which the test piece was bent without cracking.

It is noted from test results in Table 3 that tendency of crack initiation in case of T-directional bending was varied among test pieces, although any test piece was not cracked by L-directional V-bending with even a minimum radius R of 0.1 mm. A minimum radius R was 0.6 mm as for crack initiation of the sample S-1 but 1.5 mm as for crack initiation of the sample S-2, although the samples S-1 and S-2 had nearly the same yield strength. The comparative result proves that the sample S-1 has bendability better than the samples S-2 and S-3, despite its elongation smaller than S-2 and S-3. In short, a work-hardened ferritic structure is advantageous in bendability, as compared with a martensitic structure.

Table 3: Bendability of Each Samples

	Bending direction	Radius R (mm) of curvature at a top of a punch								Minimum radius R (mm)
		0.1	0.2	0.4	0.6	0.8	1.0	1.5	3.0	
S-1	L	○	○	○	○	○	○	○	○	<0.1
	T	×	×	×	×	○	○	○	○	0.8
S-2	L	○	○	○	○	○	○	○	○	<0.1
	T	×	×	×	×	×	×	×	○	3.0
S-3	L	○	○	○	○	○	○	○	○	<0.1
	T	×	×	×	×	○	○	○	○	0.8

○ represents crack-free bending, and × represents cracking during bending.

Effects of inclusions on bendability were investigated as follows:

A molten stainless steel was adjusted to the same chemical composition as the sample S-1, deoxidized with Al and then processed to a sample A-1 under the same manufacturing conditions as the above. An Al content of the sample A-1, which originated in a deoxidizing agent, was 0.006

mass %, as shown in Table 4.

By EPMA analysis, inclusions of the sample A-1 were identified as a mixture of Al_2O_3 and $Al_2O_3 \cdot MgO$, clearly distinguishable from $MnO \cdot SiO_2$ or $MnO \cdot SiO_2 \cdot MnS$ in the sample S-1. Hereinafter, the SiO_2-based inclusion in the sample S-1 is called as "silicate-type", while the Al_2O_3-based inclusion in the sample A-1 is called as "alumina-type".

Table 4: Effects of Deoxidizing Agents on Chemical Compositions

Steel Kind	C	Si	Mn	S	Cr	Ni	Al
S-1	0.068	0.38	0.39	0.006	12.4	0.40	<0.003
A-1	0.062	0.39	0.27	0.001	12.6	0.21	0.006

Test pieces JIS 13B for a tensile test were sampled from the samples A-1 and S-1 along directions-L and -T, and subjected to a tensile test for measuring yield strength and elongation. According to test results, the samples A-1 and S-1 had the same mechanical properties, as shown in Table 5. On the other hand, results of a bending test prove that the sample A-1 had T-directional bendablity apparently superior to the sample S-1, although the samples A-1 and S-1 had nearly the same yield strength, as shown in Table 6.

The above results mean that excellent bendability is imparted to a stainless steel sheet regardless of strengthening, by combination of desulfurization and deoxidation with Al for shape control of inclusions and by cold-working for formation of a work-hardened ferritic structure.

Table 5: Effects of Deoxidation with Si or Al on Mechanical Properties

	Deoxidized by	Composition of inclusions	Metallurgical structure	Sampling direction of test pieces	Y.S. (N/mm^2)	El. (%)
S-1	Si	$MnO\text{-}SiO_2$+ $MnO \cdot SiO_2 \cdot$ MnS	work-hardened ferrite	L	689	5
				T	805	3
A-1	Al	Al_2O_3+ $Al_2O_3 \cdot MgO$	work-hardened ferrite	L	691	5
				T	808	3

Table 6: Effects of Deoxidation with Si or Al on Bendability

	Bending direction	Radius (mm) of curvature at a top of a V-block								Minimum radius R (mm)
		0.1	0.2	0.4	0.6	0.8	1.0	1.5	3.0	
S-1	L	○	○	○	○	○	○	○	○	<0.1
	T	×	×	×	×	○	○	○	○	0.8
A-1	L	○	○	○	○	○	○	○	○	<0.1
	T	○	○	○	○	○	○	○	○	<0.1

EXAMPLE 2

Several stainless steels with chemical compositions in Table 7 were melted in a 30kg vacuum furnace and deoxidized by addition of an Al or Si deoxidizing agent.

Table 7: Chemical Compositions of Stainless Steels and Deoxidizing

Steel Kind	Deoxidized By	Alloying components (mass %)							
		C	Si	Mn	S	Cr	Ni	Al	Others
A-2	Al	0.05	0.47	0.27	0.001	12.45	0.23	0.004	
A-3	Al	0.01	0.54	0.82	0.001	12.10	0.20	0.008	
A-4	Al	0.15	0.62	0.30	0.003	12.40	0.24	0.004	
A-5	Al	0.07	0.54	0.24	0.003	16.45	0.20	0.008	
A-6	Al	0.06	0.39	0.45	0.003	16.75	0.21	0.004	Mo : 0.98
A-7	Al	0.01	0.38	0.24	0.001	16.77	0.25	0.006	Cu : 1.44
A-8	Al	0.02	0.32	0.95	0.002	18.40	0.20	0.010	Nb : 0.42
A-9	Al	0.01	0.32	0.21	0.003	17.00	0.11	0.010	Cu : 1.56 Nb : 0.35
B-1	Al	0.06	0.36	0.29	0.003	12.60	0.23	≤0.001	
B-2	Al	0.02	0.48	0.78	0.002	16.55	0.10	0.090	
S-4	Si	0.01	0.40	0.38	0.006	12.4	0.32	≤0.001	
S-5	Si	0.02	0.47	0.85	0.002	11.9	0.09	≤0.001	
S-6	Si	0.07	0.67	0.02	0.008	16.49	0.24	≤0.001	

The underlined figures are values out of conditions defined by the present invention.

Each stainless steel ingot was forged to a steel plate of 55mm in thickness and 100mm in width. The steel plate was ground until its thickness was reduced to 50mm. Thereafter, the steel plate was hot-rolled to thickness of 5mm.

Some hot-rolled steel sheets, wherein a martensitic phase was formed by hot-rolling, were annealed for 7 hours at 850°C and then pickled. Other hot-rolled steel sheets free of a martensitic phase were continuously annealed at 1040°C and then pickled.

As for steel kinds to be strengthened by work-hardening, steel sheets were cold-rolled to intermediate thickness of 2.3–2.8mm, continuously

annealed at 850°C, pickled and then cold-rolled again to final thickness of 1.8mm. A total rolling reduction of each steel sheet was controlled to a value within a range of 20–35%.

As for steel kinds to be strengthened by martensitic transformation, annealed steel sheets were cold-rolled to intermediate thickness of 3.0mm, re-annealed, pickled and then cold-rolled again to final thickness of 1.8mm. The cold-rolled steel sheets were subjected to heat-treatment, i.e. heating for 1 minute at 1000°C and then air-cooling, so as to reform its structure to a martensitic single phase or a ferritic/martensitic dual-phase.

Test pieces were sampled from each stainless steel sheet manufactured as the above and subjected to observation of a metallurgical structure, inclusions and surface defects. Inclusions were identified by EPMA analysis, an index of cleanliness was measured by a method regulated in JIS G0555, and a major axis of a biggest inclusion, which was observed in a microscopic view for measurement of cleanliness, was regarded as a size of the inclusion. Other properties, i.e. yield strength, elongation and bendability, were examined by the same way as Example 1.

Results are shown in Table 8. It is noted that test pieces Nos. 1–8, which were strengthened by a work-hardened ferritic structure wherein inclusions were shape-controlled by deoxidation with Al, were excellent in bendability regardless of high yield strength of 700 N/mm^2 or more, since they were bent with a minimum radius R of 0.1mm or less without cracking.

On the other hand, a test piece No. 9, which had high yield strength due to martensitic transformation, had extremely poor bendability with a minimum bend radius R of 2.5mm. A test piece No. 10, which was improved in bendability at the expense of strength by reduction in a proportion of a martensite structure, had a minimum bend radius R of 0.6mm. The comparative results prove that martensitic transformation is effective for strengthening a steel sheet but ineffective so much for improvement of

bendability.

Even in case of deoxidation with Al, an Al content shall be properly controlled for improvement of bendability. Namely, a test piece No. 11 with a shortage of Al had poor bendability due to remaining of silicate-type inclusions. A test piece No. 12, which was over-deoxidized with excess Al of 0.09 mass %, had good bendability but a defective surface.

Any of test pieces Nos. 13-15, wherein inclusions were reformed to silicate-type by deoxidation with Si, was inferior in bendability to the test pieces Nos. 1-8.

Table 8: Mechanical Properties and Bendability of Stainless Steel Sheets

Note	No.	Steel Kind	Deoxidized by	Inclusions			Structure	Y.S. (N/mm^2)	El. (%)	Minimum Bending Radius R(mm)	Surface Defects
				Type	Size (μm)	Cleanliness (%)					
Inventive Examples	1	A-2	Al	alumina	3	0.019	WF	805	3	<0.1	no
	2	A-3		alumina	2	0.023	WF	760	4	<0.1	no
	3	A-4		alumina	4	0.023	WF	823	3	<0.1	no
	4	A-5		alumina	3	0.022	WF	810	3	<0.1	no
	5	A-6		alumina	5	0.020	WF	815	3	<0.1	no
	6	A-7		alumina	3	0.018	WF	755	4	<0.1	no
	7	A-8		alumina	2	0.020	WF	771	3	<0.1	no
	8	A-9		alumina	3	0.022	WF	781	3	<0.1	no
Comparative Examples	9	A-2	Al	alumina	3	0.019	F+M	823	9	2.5	no
	10	A-3		alumina	2	0.023	F+M	567	14	0.6	no
	11	B-1		alumina +silicate	15	0.052	WF	811	3	0.6	no
	12	B-2		alumina	20	0.045	WF	768	4	<0.1	yes
	13	S-4	Si	silicate	140	0.081	F+M	578	14	0.8	no
	14	S-5		silicate	20	0.038	WF	801	3	0.8	no
	15	S-6		silicate	210	0.097	WF	815	2	1.0	no

The mark WF is a work-hardened ferritic structure, and the mark F+M is a ferritic/martensitic structure.
The underlined figures are values out of conditions defined by the present invention.

Test pieces except Nos. 9, 10 and 13 had yield strength of 700 N/mm^2 or more due to a work-hardened ferritic structure, which was formed by cold-rolling with a finish rolling reduction of 20–30%. Any of these test pieces seems to be poor of ductility from its small elongation of 4% or less, but its bendability is actually excellent. The excellent bendability is probably derived from local elongation rather than total elongation, so that the work-hardened ferritic structure effectively improves local ductility of a bent part at its outside. Moreover, stress concentration at boundaries between inclusions and a steel matrix is relaxed by proper shape-control of inclusions. Consequently, cracking is inhibited during forming the inventive stainless steel sheet to an objective profile

INDUSTRIAL APPLICABILITY OF THE INVENTION

A ferritic stainless steel sheet, proposed by the present invention as mentioned the above, has excellent bendability regardless of high yield strength of 700N/mm^2 or more, since it is strengthened by a work-hardened ferritic structure with inclusions, which have shape-controlled by deoxidation with Al. The work-hardened stainless steel sheet is useful as such without necessity of metal-plating, which is disadvantageous for environmental protection. Since the stainless steel sheet is strengthened by work-hardening, it is formed to an objective profile at a user aid without necessity of heat-treatment. Furthermore, the stainless steel with a reduced Ni content is useful as cheap material for frames and casings of home electric appliances, office automation devices and so on.